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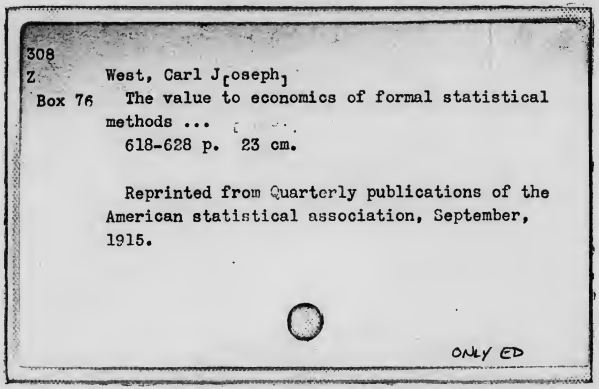

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# THE VALUE TO ECONOMICS OF FORMAL STATISTICAL METHODS.

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# THE VALUE TO ECONOMICS OF FORMAL STATISTICAL METHODS.

By Carl J. West, Ph.D., *Ohio State University.*

To afford an accurate form of summary statement of economic facts and changes, statistics must present the facts in such a way as to enable the mind to grasp them as a whole more readily and clearly. From this point of view the chief care of the statistician is to secure accurate and comprehensive field-work or counting. As a recorder and tabulator of economic data he can consider his work done either when each individual instance has been enumerated or when a definite estimate can be made of the per cent. of accuracy.

But economics demands that statistics do more than serve as a sort of bookkeeper. It is only by a study of the statistics that causes and relations can be suggested and the basis laid for empirical laws. The complexity of our economic relations requires the economist to keep in constant and close touch with concrete facts.

To what extent the prevalence of a certain disease depends on the climate or the season and to what extent on the state of sanitation can in general be determined only from an extensive statistical investigation. The intricate questions concerning the rise and fall of the interest rate are largely matters of dependence among different series of statistical facts. A general theory of prices and the gold supply needs empirical verification at every point. The fluctuations of wages and the movement of retail and wholesale prices can not be adequately understood until better and more accurate data can be obtained. Immigration and business prosperity and depression, the consumption of alcohol and the presence of poverty are essentially questions of the effect which variations in one condition or characteristic produce in related attributes or conditions.

These illustrations suggest the rather evident fact that the logic of most problems in economics is essentially the same. The ultimate aim is of course to detect and demonstrate causal





relations. The limitations or requirements of the problem may render it undesirable to attempt a more detailed formulation of the causal statement than of the type: If cause or event A is present then effect or event B will follow; or negatively, since A is not present or does not vary when B varies in value or degree of intensity, A can not be the cause of B. In general, however, the description of the causal relation can not be considered satisfactory until it is possible to state in detail just what change in the effect will follow from certain definite changes in the cause. Thus causal relations fall naturally into two broad divisions according as the characteristics or attributes are accurately determined and measured in detail, or are not measured further than to enumerate the cases in which each is present or absent.

For the purposes of statistical economics, characteristics or occurrences may be said to be causally related when, *other things being equal*, the presence of a definite amount or degree of the one is always accompanied by a corresponding amount or degree of the other; so that, in general, if one changes the other changes and if one is present and acting, a corresponding effect is to be noted in the other.

The physicist, the chemist or the engineer can make direct use of this definition since it is often possible, within working limits, to hold all other conditions constant while the conditions under consideration are varied. The engineer can so arrange his experiments that discordant and irrelevant elements can be avoided, as, for instance, when the distinct strains that a steel beam undergoes are reproduced in the laboratory and the effects measured.

But the material of the economist in degree, at least, is radically different from that of the student of the so-called exact sciences. The data of the former is always heterogeneous and complex so that it is not possible to isolate the variations and observe their relations directly; neither can it be safely assumed that all other conditions are constant while the conditions studied vary or change. For these reasons the comparatively simple and direct methods of those sciences will not apply to the solution of the problems of statistical economics. The social scientist requires methods for discovering and

demonstrating the presence of definite and uniform *tendencies* for variations in one condition or characteristic to depend on the changes in certain other conditions; that is, *correlation* methods which deal with measurements *en masse* rather than as individuals.

Thus, to test the obvious fact that during the earlier years stature increases with age, the height of 1,000 individuals at ages ranging from 6 to 25 might be determined and the average height for each age computed. In the midst of the disconcerting variations due to lack of homogeneity in conditions of health, parentage, environment, posture, etc., the general tendency for tallness to accompany heaviness would be apparent in the data.

For the treatment of the essentially *mass-aggregate* or *group* problems of *statistics* which have to do with collective and not with individual measurements, a body of theory having the definite and systematic form of the other mathematical sciences has been developed. Owing to its having been first developed for the problems of biology, however, there is need in some respects for adaptation to the requirements of the social sciences.

Every economist who makes use of concrete statistical facts must form collective judgments, must rely largely upon correlations to point out causal relations regardless of whether he consciously and formally makes use of the terminology and methods. As an illustration of a simple type of question which can not be answered by the use of informal methods take the following data of the Sheffield smallpox outbreak of 1887–1888 as given by Dr. Macdonell:*

VACCINATION–STRENGTH TO RESIST SMALLPOX WHEN INCURRED.

| | Recoveries. | Deaths. | Total. |
|---|---|---|---|
| Present | 3,951 | 200 | 4,151 |
| Absent | 278 | 274 | 552 |
| Total | 4,229 | 474 | 4,703 |

This table shows clearly that in this instance vaccination was highly effective in combating the disease. But sup-

*Elderton, *Frequency Curves and Correlation*, p. 125.



pose the same statistical material were reclassified on the basis of the presence or absence of a characteristic which we may call "sanitary" and that the following distribution was obtained:

"SANITARY"–STRENGTH TO RESIST SMALLPOX WHEN INCURRED.

| | Recoveries. | Deaths. | Total. |
|---|---|---|---|
| Present | 3,850 | 195 | 4,045 |
| Absent | 379 | 279 | 658 |
| Total | 4,229 | 474 | 4,703 |

Apparently this measure or condition is about as effective as vaccination so that it is a matter of careful study to decide which has the higher efficiency; no casual method can be relied upon to yield a satisfactory answer.

The inadequacy of informal methods may be further illustrated by the difficulty of properly "smoothing" a series of measurements by generally loose methods. To know what variations are accidental and what are significant requires first of all a thorough knowledge of the data, and to successfully eliminate the irrelevant or accidental elements without sacrificing the truly significant variations considerable skill in highly technical methods is necessary. The following table of the measurements of stature of a class of students furnishes material for an illustrative problem in "smoothing."

| Stature | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Frequency | 1 | 2 | 2 | 11 | 11 | 48 | 45 | 97 | 100 | 126 | 103 | 97 | 45 | 46 | 4 | 1 |

In these measurements one would suspect for instance that the comparatively large numbers having stature of 72 and 70 inches were not significant. The equal frequencies for 62 and 63 inches are also to be noted.

Economists have done little "smoothing" or other refining of their data for the reason that *they have not attempted to utilize more than a very small part of the information it might be made to yield.* Were it the object of this paper to discuss the value of individual methods and processes the idea of the "probable error" and of the various measures of correlation

would be illustrated. But enough has been given to show the general value and especially to suggest what is doubtless the most important value of formal methods for economics: *that if economics is to make use of more than the most obvious statistical facts and relations it must employ methods adequate to the bringing out of the significance of the data.*

It is not meant to imply that an elaborate formula is always or even ordinarily essential to the demonstration of a conclusion in statistics. But the statistician and economist should be acquainted with the general methods in order to obtain the advantages of sharply defined technical concepts and of systematic and generally accepted habits of thinking and ways of attacking a statistical problem. Only then can it be correctly decided, for example, when the most superficial methods of estimating causal connections are sufficient; when graphic methods give results with all the accuracy that the data warrants or the problem in hand demands; and when it is advisable to employ more detailed and exact methods. *Thus the economist has need for a science of statistics similar to the need of the biologist for chemistry and microscopic technique and of the engineer for physics and mathematics.*

An extensive employment of statistical data means that the material must be collected as representative or typical data and not by complete enumerations. The expense and labor involved render the second method prohibitive, and besides few objects of economic inquiry lend themselves to the process of complete enumeration. Indeed, much can be said in favor of the argument that better data for the purposes of economics can be obtained by carefully selecting the material. Moreover, though the data may be gathered by an exhaustive process of counting it must be considered as typical, as a true pattern of what may be expected to occur again and again under similar conditions, if it is to be of value in establishing a principle or verifying a deduction. Reliable and effective work with typical data can not be done without an extensive acquaintance with statistical theory. For this reason, if for no other, statistical economics can not be developed to a significant extent until methods adapted to its peculiar needs have been worked out and popularized among economists.



It may well be asked what effect the introduction of more formal methods may tend to have on the quality of the empirical work of economics and on the effectiveness of economic work in general.

Accuracy in the collection or production of statistical facts and accuracy in determining and stating the degree of confidence that can be placed in the data is a matter of fundamental and vital importance for economics. The statistician who realizes how little has been done in this respect and how difficult it is to secure proper appreciation of the necessity for extreme carefulness and caution in accepting statistical material may well feel apprehensive of the effect of the introduction of new and apparently easy methods of deducing striking results. Perhaps the most suggestive way of estimating the probable influence of the extensive adoption of statistical methods on the quality of the data is by studying the conditions which somewhat similar circumstances have produced in other sciences. It is also of interest to note the working relations that have gradually grown up between the experimental and empirical elements on the one side and the so-called theoretical parts on the other.

The development of profound mathematical methods in physics has not tended to lessen the accuracy of the laboratory work but to increase it. On the somewhat slender basis of Hertz's experiments, Maxwell produced his mathematical theory of electromagnetism and ether waves. On the basis of and as a result of this theory, Marconi invented the wireless telegraph. This working together of theory and experiment along with the feeling that no result can be accepted until it has received both theoretical and experimental verification is of definite and positive significance for economics. If the two aspects can get on so well in the field of physical science, why not in the social sciences?

Psychology is similar to economics in that it deals with data subject to large variations in the individual measurements so that only aggregate methods can be employed. There is much discussion among psychologists regarding certain points of method, but it is generally agreed that experimental results must be reduced before they become completely intelligible.

An important consideration from our point of view is that the introduction of somewhat complicated methods for determining correlation and variation has stimulated both the production of experimental data and the critical discussion of such data, which can but result in better and more accurate experimental work. Moreover, the results in psychology tend to show that not only is the accuracy of the observational work increased but also the science itself is greatly enriched by the introduction of formal methods of reducing the statistical data.

The history of biology since the time of Darwin is especially instructive. Darwin, both by his example and by the stimulating influence of his work, gave great impetus to observational methods in biology. The researches that have resulted consist essentially of studies in the comparative variations among different biological classes and of the inter-relations of such variations. These variations are often small so that appropriate and adequate methods of dealing with the peculiar problems of the data are imperative. Professor Pearson in his "Mathematical Contributions to the Theory of Evolution" developed the working rules and principles which have been almost universally adopted by statistical biologists. Since so much of this statistical work is largely routine in character the results have been satisfactory on the whole even though few biologists have the mathematical training to understand the formulas.

However, the extensive employment in this mechanical fashion of highly developed but little understood methods very naturally has resulted in mistakes which if not so serious would be ridiculous in some instances. Using six- or seven-place logarithms with data subject to a high per cent. of error; smoothing curves by methods involving an overwhelming mass of arithmetic when a better curve could be obtained by simple graphic means; failing to realize that the "probable error" is a safe guide only for homogeneous data; losing sight of the necessary limitations of the theory of the coefficient of correlation, are only a few of the statistical sins which some biologists have committed in the name of scientific methods.

Aside from the useless expenditure of labor, computing to



so much greater length than the data warrants would not be a matter of great concern were it not for the fact that such a show of accuracy is often positively misleading. The wide margin of error in the original data is presently forgotten and the results taken with all their apparent accuracy.

A class of scientists trained, as are the biologists, in systematic thinking would not be guilty of such loose reasoning if they thoroughly understood the methods they were using. Nothing but mere routine and that only when done under immediate and responsible supervision can be safely trusted to persons with inadequate preliminary training. The statistician should not make use of a formula or method until he thoroughly comprehends the assumptions on which it is based and until he knows the conditions and limits of its validity. *And further, a formula should not be used unless the results derived by it can be clearly interpreted in terms of the initial data and conditions.* The biologist and economist can safely call upon the mathematician to derive the formulas which make it possible to pass from the raw data to the finished result, but the mathematician can not always be trusted to estimate the accuracy in the raw data themselves or to tell what formulas are the most appropriate under the given circumstances; this absolutely essential part can be done only by one who is thoroughly conversant with the statistical material and who has at least a reasonably comprehensive idea of the methods.

Thus the effect on the scientific character and value of the inductive or experimental work in those sciences in which there have been applications of formal statistical methods seems to give no ground for a fear that the quality of the statistical work in the social sciences will be lowered by careful and systematic use of more standardized methods. Aside from the support which a study of the history of the other sciences may lend to this conclusion, it is logically sound to expect that the character of statistical work will improve as more attention is given to technical principles. It is only by the building up of a body of systematic principles and methods that a subject of study can be raised to the dignity of a science. The mere fact of the existence of formal methods imparts a definiteness which tends to stimulate systematic thinking even though

the actual methods are not consciously or formally made use of. Besides there is always a gain in doing routine and detail work according to orderly, systematic, and generally accepted methods. For instance, the consciousness that the methods employed have been tried and proved produces a confidence in the results which can be obtained in no other way. The too frequently encountered opinion that one "can prove anything by statistics" is due partly to the lack of generally recognized methods of measuring the degree of connection between related series of events, and partly to the failure to critically value the reliability of the data, and much of this failure is due to the lack of simple but uniformly applicable methods of measuring such reliability. The non-technical person is quite ready to rely on the conclusions of specialists provided the specialists are reasonably agreed among themselves. But with methods as tentative and dependent on personal peculiarities as are the ordinary methods of statistics such an agreement is impossible.

An increased appreciation of statistical work is bound to react favorably on social science in general. It is possible that economics should become more professionalized than at present. Most individuals of average intelligence would assent to the statement that the trained economist is better able to decide complicated economic questions than are they themselves, but if it came to a matter of personal concern it is doubtful whether the opinion of the specialist in economics would be held in such respect as would that of the physician or lawyer. While there is no particular reason for thinking that formal statistical theory can or should become popular in the generally accepted sense of the term so that anyone could make use of it, yet by giving to statistics, and hence to much of economics, uniformity of method and quantitative definiteness, making possible more elaborate and thoroughgoing investigations, the science would become more professionalized with a consequent increased respect for economics on the part of the public.

However, economics can not hope to escape the experimentation of those who are fascinated by the possibilities of the newer developments in statistical methods but who do not adequately realize the inherent limitations of their data or who do not have sufficient acquaintance with the working



principles of the methods to use them discriminately. To do trustworthy and effective work in statistical economics, the economist must be a statistician, and especially must understand the material from which the data are taken and must know the degree of confidence that the data warrant. To determine the accuracy of the data and to so analyze the numerical facts as to obtain the maximum amount of information from them requires an extensive training in somewhat complicated arithmetic and theory.

But there are few economists with the mathematical equipment necessary for statistical purposes and still fewer mathematicians with an appreciation of the problems of the economist. The physicists have adjusted themselves to a similar situation so that most physicists know considerable mathematics and usually the mathematical student has turned to physical science for a minor study. While this arrangement has worked well for the science in question persons so trained are not particularly qualified to take up statistical investigations. The material of the social sciences is so radically different from that of the physical sciences that it is extremely hard for the physicist, for instance, to adjust his habits of thinking to the new standards. It is very easy for five-place standards of accuracy to be in this way carried over into a field where the figures may often have a margin of error of several per cent.

If students of mathematics are encouraged to take up economics and the more statistical parts of social sciences in general as secondary subjects, great improvements and simplifications in statistical methods will be possible. Only in this way can the economist obtain the aid which experience in other sciences shows to be necessary.

On the other hand, the student of economics must be better trained in mathematics; not so much in the material which makes up the greater part of the courses in mathematics as planned for engineering students as in courses having the needs of the social sciences more in view. Such a course should include detailed practice in algebraic manipulation and in certain especially useful topics of analytic geometry and should lay emphasis on the subject of probability. It is no doubt ad-

visable to have a separate course for the more technical topics of statistical methods such as the smoothing of data, curve fitting, measures of accuracy, correlation, etc. With these two courses students not desiring to specialize in statistics can obtain a fairly comprehensive knowledge of statistical methods by taking the technical course only, while the student expecting to make considerable use of statistics would of course need the more extensive mathematical training.

The relative extent of these two courses should probably vary to accord with local conditions and requirements. It seems quite certain, however, that the practice of devoting a few lectures to the more technical phases of statistical methods in connection with courses in economic statistics can not be productive of results of great value, because such courses are ordinarily given by persons primarily interested in some phases of economics and consequently not likely to have great interest in so characteristically formal a study as statistical methods or mathematics; and because the subject is too extensive and complicated for so brief a presentation. The slight acquaintance gained in this way may indeed be a positive detriment if it does not impress the student with the extent and difficulty of the theory and with the necessity for extreme care and caution in its application. It is easy to lose sight of the fact that a discriminating statistical judgment can be attained only by long training and practice.

It would seem therefore that the most desirable arrangement is for the course in statistical methods to be given by an instructor who is especially interested in methods and formal theories and who has had the benefits of an appropriate mathematical training, and for this course to be followed by the courses in economic statistics and the other courses in social science which make use of statistics and in which formal methods can be employed to advantage.

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